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UNIFIED THEORY OF LIGHT

Abstract:
In this article, we propose a unification of the 2 possible behaviors (corpuscular or wave) of light and of electromagnetic wave.
The first part presents a unified theory of monochromatic electromagnetic plane waves. We see in applications that this theory is in agreement with classical elements of the presently admitted theory of monochromatic plane waves (plane wave reflected on a perfect conductor, plane wave reflected and transmitted between 2 mediums having different indices of refraction n_1,n_2).
We will see that the Unified Theory of Light (U.T.L) presented here brings to a new expression of the density of electromagnetic energy of interacting plane waves.
The second part presents a theory of unification of optics, and especially of phenomena for which we classically use the wave behavior of light (diffraction and interferences). We will see that U.T.L uses results of Quantum Theory of absolute variables that we exposed in another article (ref 1).We will give an interpretation of classical experiments by U.T.L.

Key words: light- monochromatic waves- physical optics-refraction.

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This article, Unified Theory of Light (U.T.L) presents a unification of the 2 possible behaviors of light and of electromagnetic waves.
Presently we sometimes consider light as a wave and sometimes as constituted of photons. If we want to unify those 2 behaviors, then we are going to see that it appears very interesting phenomena. Nonetheless, we are going to see that this unification is possible.

Concerning electromagnetic waves, U.T.L brings to the conclusion that the classical formula giving the density of electromagnetic energy of several superposed monochromatic plane waves cannot be correct. Nonetheless, we will show in the first part devoted to unification of wave and corpuscular aspect of monochromatic plane waves that interpretation by U.T.L is compatible with classical experiments (reflection of a plane wave on a perfect conductor, reflection and transmission of a plane wave in normal incidence between mediums, photon changing of medium.).

Concerning optics, we remind that we consider light as a wave in order to explain phenomena of interferences and of diffraction. If we want a unified theory for those phenomena, we must use a new quantum theory, Shocks Quantum Theory, that we exposed in a previous article (reference 1). Nonetheless, in this article, we will only use the fundamental Principle of this theory, that we will recall before using it. Nonetheless, it is important to know that it exists a complete theory, different from the classical Quantum theory, that is compatible and is based on this Principle.

2. UNIFIED THEORY OF ELECTROMAGNETIC PLANE WAVES

2.1 Theory

2.1.1 *Recall- Electromagnetic wave.*

We recall that according to the classical theory of electromagnetism, the density of electromagnetic energy in the vacuum is:

$$w = \frac{1}{2}(\varepsilon_0 \mathbf{E}^2 + \frac{\mathbf{B}^2}{\mu_0}) \qquad (1)$$

Now we are going to consider a plane electromagnetic wave moving in the vacuum in the direction of the unitary vector **u**. According to the present theory:

$$\mathbf{E}.\mathbf{u}=0,\ \mathbf{B}.\mathbf{u}=0,\ \mathbf{B} = \frac{\mathbf{u} \wedge \mathbf{E}}{c} \qquad (2)$$

Consequently the density of energy of a plane monochromatic wave in the vacuum is:

$$w=\varepsilon_0\mathbf{E}^2 \qquad (3)$$

We will keep this expression in U.T.L

2.1.2 *Interpretations of photons in U.T.L.*

In U.T.L, we consider that photons are corpuscles that have a length λ in the direction of their propagation. We will call the head and the queue of the photon its 2 extremities with obviously the queue at the back and the head forward.
If we have a point P crossed by a photon, we consider that the period $T=1/\nu$ of the photon measured in P is the time measured by a clock coinciding with P separating the arrival of the head and of the queue of the photon.

velocity v relative to P, we have the classical relation

2.1.3 *Energy of photons*.

We know classically that the energy of a photon is:
$E=h\nu$ (4)

In fact, in the Theory of Ether with Gravitation (T.E.G) presented in the article T.E.G (ref 7), we distinguished the absolute frequency of a photon ν_A from its apparent frequency ν_e, and the real expression of the energy of a photon was, in a gravitational potential V:
$E=h\nu_A=h\nu_e(1-V/c^2)$ (5)

2.1.4 *Unified interpretation of a monochromatic sinusoidal plane wave in the vacuum*.

Let us consider a monochromatic sinusoidal plane wave in the vacuum, moving in the direction O**x**.
The Electromagnetic field associate to this wave is:
$E_x=0,\ E_y=E_{0y}\cos(\omega(t-x/c)+\varphi_{0x}),\ E_z=E_{0z}\cos(\omega(t-x/c)+\varphi_{0z})$ (6)

So in the proposed U.T.L, the unified interpretation is:
a)The wave is constituted of photons moving in the same direction of propagation O**x** as the wave with a velocity c.
b)The apparent frequency of those photons is $\nu_e=\omega/2\pi$.
c)The number of head of photons N(dV) inside an element of volume dV in a place in which the electromagnetic density w is constant is:

$$N(dV)=\frac{wdV}{h\nu_A} \qquad (7)$$

We remind that $w=\varepsilon_0\mathbf{E}^2$ and that:
$h\nu_A=h\nu_e(1-V/c^2)$ (8)

Because the energy of each photon is $h\nu_A$, we obtain as expected that the energy of photons in the element of volume dV is equal to wdV.

We remark that if we set t-x/c=K, K being constant, then **E**(t-x/c) is constant and consequently the local electromagnetic density $w(t-x/c)=\varepsilon_0\mathbf{E}^2$ is constant.
But t-x/c =K with K constant means:
x=ct-Kc (9)

Consequently the constant electromagnetic density of energy of a plane wave for x=ct-Kc is compatible with our unified interpretation that implies the existence of volume moving at velocity c in the direction Ox and containing the same numbers of photons, so with an electromagnetic energy density w constant.

2.1.5 *Unified interpretation of a monochromatic sinusoidal plan wave in a medium of refractive index* n.

Let us consider a monochromatic sinusoidal plane wave moving in the direction O**x** in a medium having a refractive index n.

...xpression of the electromagnetic field associate to a ... :

$E_x=0$, $E_y=E_{0y}\cos(\omega(t-x/v)+\varphi_{0x})$, $E_z=E_{0z}\cos(\omega(t-x/v)+\varphi_{0z})$ (10)

Consequently, in complete analogy with the case in the vacuum, the interpretation by U.T.L is:

a)The wave is constituted of photons moving in the direction Ox with a velocity v.

b)The apparent frequency of the photons is $\nu_e=\omega/2\pi$.

c)The number dN(dV) of heads of photons inside an element of volume dV in a point of electromagnetic density w is:

$$N(dV)=\frac{wdV}{h\nu_A}=\frac{wdV}{h\nu_e(1-V/c^2)} \qquad (11)$$

Here, w is the density of electromagnetic energy inside the medium.

In what follows, in order to simplify we will take a null gravitational potential, consequently $\nu_A=\nu_e=\nu$ and the energy of a photon is $E=h\nu_e=h\nu$.

2.1.6 *Photons changing of a medium.*

Let us suppose that we have the vacuum for x<0 and that there is a medium of refractive index indices n=c/v for x>0.

We suppose that there is a monochromatic sinusoidal plane wave moving in the vacuum in the direction O**x**.

Then we know that there is a transmitted plane wave in the medium, having the same expression as in equation (10), so with the same pulsation ω as the incident plane wave.

So our interpretation in which the energy of photons is $E=h\omega/2\pi$ is in agreement with the fact that we can expect that the energy of photons remain unchanged after having changed of medium.

We remark that the length of wave λ_n of the photons inside the medium is related to their length of wave λ in the vacuum by the relation:

$$\lambda_n=vT_n=vT=\frac{v}{c}\times Tc=\frac{\lambda}{n} \qquad (12)$$

2.1 Applications

2.1.1 *Reflection of a plane wave on a perfect conductor.*

We remind that a perfect conductor has an infinite conductivity, so inside it:

E=0, ρ=0, **B**=0, **j**=0. (13)

Then we consider that there is the vacuum for x<0, and a perfect conductor for x>0.

We consider an incident plane wave in the vacuum (x<0) moving in the direction O**x**.

We suppose that the incident wave is associate to the electromagnetic field :

$\mathbf{E}_i=E_0\cos(\omega(t-x/c))\mathbf{u}_y$ $\mathbf{B}_i=(E_0/c)\cos(\omega(t-x/c))\mathbf{u}_z$ (14)

Then according to classical theory of electromagnetism, the electromagnetic field associate to the reflected wave is:

$\mathbf{E}_r=-E_0\cos(\omega(t+x/c)\mathbf{u}_y$ and $\mathbf{B}_r=(E_0/c)\cos(\omega(t+x/c))\mathbf{u}_z$ (15)

We consider in U.T.L that the total energy density is the sum w_i+w_r of the energy's density of the reflected wave and of energy's density of the reflected wave.

So the energy density of the incident wave is:

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and the energy density of the reflected wave is:

$w_r = \varepsilon_0 E_0^2 \cos(\omega(t+x/c))$ (17)

We see that the reflected wave appears to be composed exactly of the photons composing the incident wave.

Indeed first we remark that according to our unified interpretation of plane wave, the photons of the reflected wave have exactly the same frequency and move in the opposite direction of the photons of the incident wave.

Moreover we can show that if we consider a very small interval of time dt, then in dt the number of photons of the incident wave arriving on the plane x=0 is equal to the number of photons of the reflected wave leaving the plane x=0.

Indeed let us consider a very small interval of time dt. We consider that during dt the field $\mathbf{E}_i$ remains constant on the plane x=0, and consequently also the field $\mathbf{E}_r$.

So if we consider an element of surface dS of the plane x=0, during dt it arrives $N_i(dt)$ photons of the incident wave on dS with:

$$N_i(dt) = cdtdS\frac{w_i}{h\nu} = cdtdS\frac{\varepsilon_0 \mathbf{E}_i^2}{h\nu} \quad (18)$$

During dt it leaves a number of photons $N_r(dt)$ of the reflected wave from dS with:

$$N_r(dt) = cdtdS\frac{\varepsilon_0 \mathbf{E}_r^2}{h\nu} \quad (19)$$

So we obtain $N_r(dt)=N_i(dt)$ because on the plane x=0 we hace $\mathbf{E}_i^2 = \mathbf{E}_r^2 = E_0^2\cos(\omega t)$.

According to present theory of electromagnetism, the energy density is:

$$w_{cl} = \varepsilon_0 \frac{(\mathbf{E}_i + \mathbf{E}_r)^2}{2} + \frac{(\mathbf{B}_i + \mathbf{B}_r)^2}{2\mu_0} \quad (20)$$

This expression is different from the expression in U.T.L:

$w_{U.T.L} = w_i + w_r = \varepsilon_0 \mathbf{E}_i^2 + \varepsilon_0 \mathbf{E}_r^2$ (21)

2.2.2 *Reflection and transmission of a plane wave in normal incidence between 2 mediums.*

We suppose that the plane x=0 separates 2 mediums having as refractive index n_1 (for x<0) and n_2 (for x>0).

We consider a sinusoidal monochromatic plane wave inside the space x<0 moving in the direction O**x**.

We suppose that the electromagnetic field associate to this incident wave is:

$\mathbf{E}_i = E_0 \cos(\omega(t-x/v_1))\,\mathbf{u}_y$ and $\mathbf{B}_i = (E_0/v_1)\cos(\omega(t-x/v_1))\,\mathbf{u}_z$ (22)

According to classical theory, the transmitted wave is associate to an electromagnetic field having the amplitude:

$$E_t = tE_i = \frac{2n_1}{n_1+n_2}E_i \quad \text{and} \quad B_t = \frac{E_t}{v_2} \quad (23)$$

And the reflected wave is associate to an electromagnetic field having the amplitude:

rB_i (24)

So we obtain:

$\mathbf{E}_t$ = tE$_0$ cos(ɤ (t-x/v$_2$)) $\mathbf{u}_y$, $\mathbf{B}_t$= (tE$_0$ /v$_2$)cos(ɤ (t-x/v$_2$) $\mathbf{u}_z$

$\mathbf{E}_r$ = rE$_0$cos(ɤ (t+x/v$_1$) $\mathbf{u}_y$, $\mathbf{B}_r$ =(-rE$_0$/v$_1$)cos(ɤ (t+x./v$_1$) $\mathbf{u}_z$ (25)

According to our unified interpretation of monochromatic plane waves, we see that photons of the reflected and of the transmitted wave keep their frequency (and their energy) and move in the expected directions with also the expected velocity.

As previously, we can show that if dt is a very small interval of time, the number of photons of the incident plane wave arriving on the plane x=0 is equal to the sum of the number of photons of the incident and of the numbers of photons of the reflected wave leaving the plane x=0.

We recall that in a medium of refractive index n, the electromagnetic density of a plane wave is according to classical theory of electromagnetism w = Ů$\mathbf{E}^2$ =Ů$_0$n$^2\mathbf{E}^2$. We will keep this expression in U.T.L.

We consider a very small interval of time dt, such that we can consider that the electromagnetic field remains constant. We also consider an element of surface dS of the plane x=0.

According to our interpretation of plane wave, the number of photons of the incident wave arriving on dS within dt is N$_i$(dt) with:

$$N_i(dt) = \frac{v_1 dtdSw_i}{h\nu} = \frac{v_1 dtdS\varepsilon_1 \mathbf{E}_i^2}{h\nu} = F_i \frac{dtdS}{h\nu} \qquad (26)$$

The number of photons of the reflected wave leaving the plane x=0 in dt is exactly the same way:

$$N_r(dt) = \frac{v_1 dtdS\varepsilon_1 \mathbf{E}_r^2}{h\nu} = F_r \frac{dtdS}{h\nu} \qquad (27)$$

And the number of photons of the transmitted wave leaving dS in dt is:

$$N_t(dt) = \frac{v_2 dtdS\varepsilon_2 \mathbf{E}_t^2}{h\nu} = F_t \frac{dtdS}{h\nu} \qquad (28)$$

We will have the equality N$_i$(dt)=N$_r$(dt)+N$_t$(dt) if:

$F_i=F_r+F_t$ (29)

And we have:

F$_i$=v$_1$Ů$\mathbf{E}_i^2$=(c/n$_1$)n$_1^2$Ů$_0\mathbf{E}_i^2$= Ů$_0$cn$_1\mathbf{E}_i^2$ (30)

F$_r$=v$_1$Ů (rE$_i$)^2)=Ů$_0$cn$_1\mathbf{E}_i^2$r^2=r^{2}F$_i$=RF$_i$ (31)

F$_t$=v$_2$Ů$_2$ (tE$_i$)^2=(n$_2$/n$_1$)t^2(Ů$_0$cn$_1\mathbf{E}_i^2$)=(n$_2$/n$_1$)t^{2}F$_i$=TF$_i$ (32)

With $R=r^2$ and $T= (n_2/n_1)t^2$. (33)

So we obtain the expected result, because R+T=1:

N$_i$(dt)=N$_r$(dt)+N$_t$(dt). (34)

reflected plane wave and the transmitted plane wave t plane wave. As previously the energy density in the medium 1, according to U.T.L is w_r+w_i, and not:

$$w_{cl} = \varepsilon_0 \frac{(\mathbf{E}_i + \mathbf{E}_r)^2}{2} + \frac{(\mathbf{B}_i + \mathbf{B}_r)^2}{2\mu_0} \qquad (35)$$

2.2.3 *Superposition of several monochromatic sinusoidal plane wave.*

According to what precedes, if we have several monochromatic sinusoidal plane waves in the vacuum associate to the electromagnetic fields ($\mathbf{E}_1$,$\mathbf{B}_1$),é ($\mathbf{E}_n$,$\mathbf{B}_n$), according to U.T.L, the total energy density is the sum of individual energy density of the plane waves, and not the classical expression taking the sum of electric fields and the sum of magnetic fields in a point.

3. UNIFIED THEORY OF OPTICAL PHENOMENON

3.1 Theory

We remind that in an article, Shocks Quantum Theory (ref 1) we proposed that many quantum phenomena were due to shocks, meaning to instantaneous (or very brief) interactions modifying in a discontinuous way , and in a random way the physical properties of a system.
Shocks could occur for instance when a system (atom, particle, photon..) crossed an obstacle or a discontinuity (screen, small aperture, other systemé)
According to S.Q.T, and contrary to classical Quantum Theory, physical variables were completely definite between 2 shocks, and were not affected by observation (except by the classical possible physical interactions with the measure instruments).
In optics, we know that many phenomena are interpreted considering light as a wave. It appears that we can unify corpuscular behavior and wave behavior of light in those phenomena if we use the concept of shocks when light crosses an obstacle.
Again we will assume that a monochromatic luminous wave of pulsation ɤ is constituted of photons of frequency з=ɤ /2´ .
Moreover, we will assume that the laws of geometric Optics are valid for photons, meaning for the corpuscular aspect of light.

3.2 Applications

3.2.1 *Interferences on a screen parallel to the direction S1S2 of the secondary sources.*

This experiment is very classical (ref 4,5,6). Let us describe it succinctly:

We have a frame (O,x,y,z) and 2 coherent sources S_1 an S_2 in the plane z=0 and on the axis Ox, with S_1S_2=a , O being the middle of [S_1,S_2], and if we have a screen situated in the plane z=D, with the assumptionsã(x^2+y^2) <<D, and a<<D, we obtain an interference fringes separated from:

$$i = \frac{\lambda_0 D}{na} \qquad (36)$$

with ə$_0$ is the length of wave and n is the refractive index.
It is clear that we obtain this value if we consider that there is a shock situated in the segment [S_1,S_2].

emitted from O, and that if ɗ is their angle with the …pends only from ɗ with maxima of intensity separated from $\varphi\alpha_M=\partial_0/na$, then the interference fringes are clearly separated from $D\varphi\alpha_M=i$
Consequently we see on this Example that S.Q.T permits to unify the 2 behaviors of light in order to explain interferences.

3.2.2 *Interferences localized at the infinite between 2 waves.*

This experiment is also very classical:
We have a blade with parallel faces and a source S, the blade having the index n, we know using classical theory of electromagnetism that on a screen parallel to the blade and situated at large distance from the blade, we obtain concentric circles, that are predicted classically as the result of an interference between 2 waves.
Here also it is clear that if there is a shock on the blade, then photons can have the suitable direction to give the obtained concentric circles. We can verify this if we make several different experimental observations on screens at different distances from the blade. We can expect (but it is not compulsory) that photons come from the orthogonal projection of S on the blade, by analogy with the first considered experiment of interferences.
We can propose the same analysis for the case of interferences of N waves at the infinite, because here also we obtain concentric circles that can be consequence of a shock on the blade.

3.2.3 *Diffraction of light.*

We recall that diffraction occurs when a monochromatic luminous beam crosses an obstacle.(diaphragm). So we are exactly in the condition of a shock.
We can verify that in all cases of diffraction (rectangular aperture, slit, circular diaphragm..) the intensity of the final figure depends only of the direction **u** taken by light after the obstacle. Consequently, it can be explained by a shock in the diaphragm after which the intensity of photons in the direction **u** is precisely the one expected considering light as a wave , as we do in physical optic in order to obtain the diffraction figure.

4.CONCLUSION

So U.T.L (Unified Theory of Light) permits to unify corpuscular and wave behavior of the light and more generally of electromagnetic waves. This unified theory is clearly necessary. As expected for such a theory it appears in U.T.L that both aspects are complementary and not contradictory. We see that U.T.L permits to interpret phenomena in which presently only wave behavior of light or of electromagnetic wave was considered. We have seen that unified interpretation leaded to the conclusion that energy density of superposed plane waves was different from its classical expression.
Concerning physical optics, we see that unified interpretation leaded to very amazing phenomena:
It occurs shocks such that they expresses exactly the future behavior of light as a wave. So during a shock, photons have a behavior anticipating the future behavior of light as a wave, that we can predict classically using classical theory of diffraction and of interferences.
So U.T.L is necessary in order to understand complementary aspects, and compatibility of 2 behaviors of light, corpuscular or wave.

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